Journal of Forensic and Legal Medicine 19 (2012) 280–284

Contents lists available at SciVerse ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

Estimation of stature from upper limb anthropometry in Iranian population

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ARTICLE INFO

Article history:
Received 14 April 2011
Received in revised form
23 November 2011
Accepted 27 December 2011
Available online 31 January 2012

Keywords:
Forensic anthropology
Upper limb anthropometry
Personal identification
Stature estimation

ABSTRACT

Objective: Personal identification is an essential issue when mutilated and amputated limbs or parts of the body are found in mass disasters. Estimation of the stature from the size of different parts of the body is one of the most important items in personal identification. The aim of this study was to estimate the stature from upper limb anthropometry.
Materials and methods: Height, left upper limb, left arm, left forearm, length and breadth of the left hand, and length of the left second to fifth fingers were measured on 100 right-handed Iranian medical students aged between 21 and 26 years from February to may 2010.
Results: After analyzing the datas, it was shown that there is a meaningful relation between the stature and upper limb dimensions ($p < 0.05$), [correlation coefficients ranged from 0.310 to 0.696 in males and 0.299 to 0.735 in females].
Conclusion: The regression formula derived in this study can be used for forensic pathologists and Anthropologists.

1. Introduction

Stature is considered as one of the special important parameters for personal identification that is essential in forensic medicine cases. Sometimes, we find fragmented bodies as soft tissue remains in murders, accidents, or mass disasters and natural events, in which, estimation of the stature and determination of the gender is essential for personal identification.

Various studies have been published on estimating the stature from skeletal remains.[1–4] Stature and the length of the long bones are affected by many factors such as genetics, nutrition, environment, gender, age, and physical activity that is widely different between different ethnic origins.

The relation between various dimensions of the upper limb like arm, forearm, finger and phalanges and stature has been reported in the numerous related studies.[5–11]

Therefore, according to the lack of published studies about the relationship between upper limb dimensions and the stature of Iranian population, the present study aims to find a proper formula to calculate the stature from the upper limb dimensions.

2. Materials and methods

A total of 100 Iranian students (50 males and 50 females) aged between 21 and 26 years were evaluated. All of them were right-handed and the measurements were performed on the left upper limb by a single observer from February to May 2010 between 2 PM till 3:30 PM in the same place and position with sufficient light. Cases with the history of nutritional, musculoskeletal, and congenital or acquired deformity or gonadal dysgenesia (such as Turner syndrome), or amputated left upper limb were excluded.

"The left upper limbs of right-handed persons were chosen because of insignificant bilateral variation in both sexes.[12,13]"

After brief explanation and obtaining written consents from them and physical examination, height length was measured in standing position (barefooted; the length between vertex and floor) while back of the shoulders, buttocks, and heels were touching the wall and upper limbs were vertically pointing downwards.

Length of the hand was measured from mid-point of distal wrist crease to the tip of the middle finger[8,14–17] after asking the cases to sit down and supinely place their hand on a flat hard horizontal surface with thumb in abduction and other fingers in extension and adduction positions[7,12–14,17,18] and forearm directly in line with the middle finger, Hand breadth was measured from the radial side of

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doi:10.1016/j.jflm.2011.12.034

the second metacarpophalyngeal joint to the ulnar side of the fifth metacarpophalyngeal joint. Length of the second to fifth fingers was measured in the same position from proximal finger crease to the tip of the finger.[9] All hand dimensions were measured with calipers in millimeter with precision of 0.02 mm.

The subjects were asked to stand up and straight their left upper limb to make a 90-degree angle with the trunk. Maximum length of the upper limb was measured from the inferior border of the acromion process to the tip of the middle finger. Maximum length of the arm and forearm was measured as the length between the inferior border of the acromion and head of the radius, and head of radius to distal wrist crease, respectively. These last three dimensions were measured with tape-measure in centimeter with the precision of 0.5 cm. The measurements were taken and repeated for 3 times and the mean measures were recorded. All data was analyzed using SPSS software version 11.5, Pearson's *t*-test, and correlation and regression models. *P*-value less than 0.05 was considered as significant.

3. Results

Scatter-plot matrices representing the relationships between the dependent variable and the explanatory variables are shown in Figs. 1 and 2.

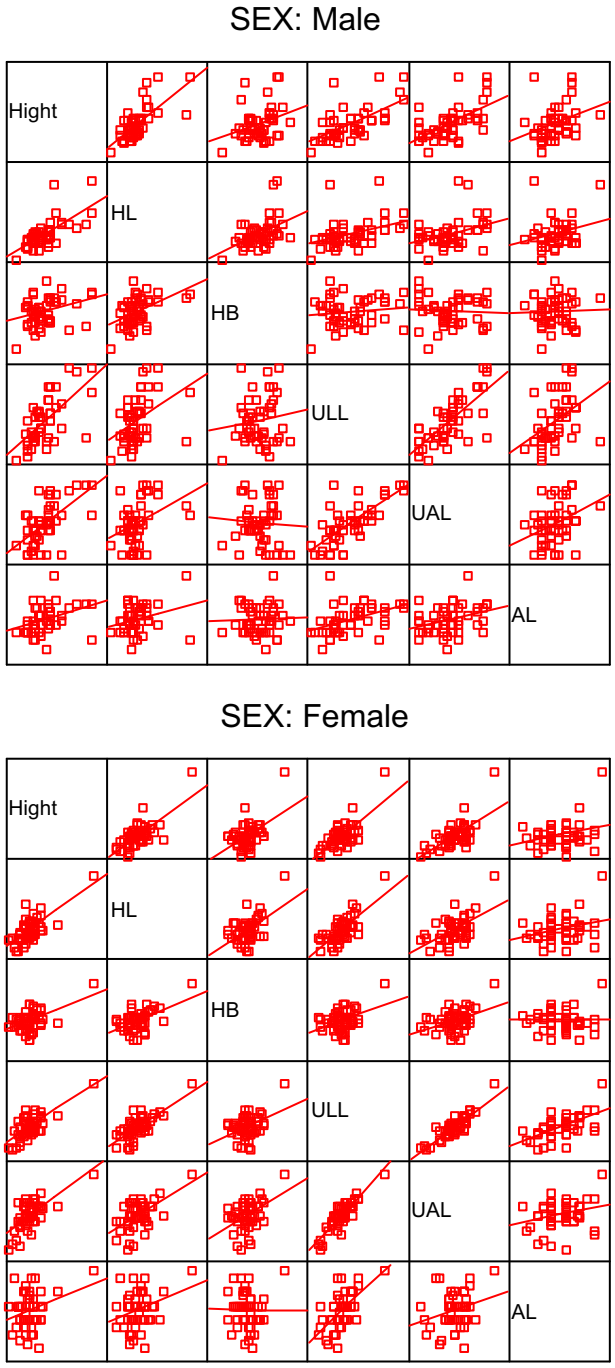

Fig. 1. Scatter-plot matrix representing the relationships between the stature (*S*) and hand length (HL), hand breadth (HB), upper limb length (ULL), arm length (UAL), forearm length (FAL) in males and females respectively.

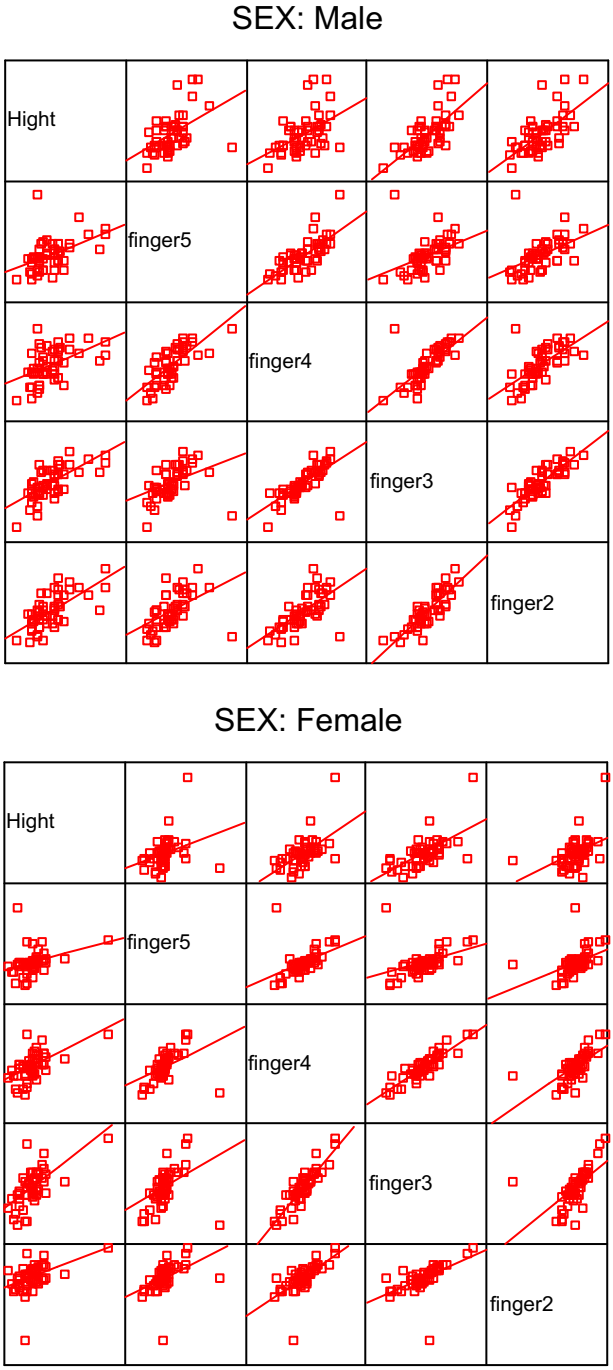

Fig. 2. Scatter-plot matrix representing the relationships between the stature (*S*) and length of the 2nd. to 5th fingers (FL) in males and females respectively.

Table 1
Descriptive statistics of stature and anthropometric parameters of left upper limb in both genders; [arm, forearm, length and breadth of the hand (cm), and length of the second to fifth fingers (mm)].

		Mean	SD	95% CI		Min	Max
				Lower lim.	Upper lim.		
Age	Male	24	1	23	24	21	26
	Female	24	1	23.5	24	22	26
	Total	24	1	23.5	24	21	26
Stature	Male	176	6	174	177	164	194
	Female	162	6	160	164	152	194
	Total	169	9	167	171	152	194
Upper limb length	Male	76.1	3.3	75.1	77	70.5	83.5
	Female	70.2	3.5	69.2	71.2	63	83.5
	Total	73.1	4.5	72.2	74	63	83.5
Arm length	Male	36.2	2.1	35.6	36.8	23	40
	Female	33.5	2.2	32.9	34.1	28	40
	Total	34.9	2.5	34.4	35.3	28	40
Forearm length	Male	21.6	1.7	22.1	22	18	27
	Female	19.7	1.3	19.3	20	17	22.5
	Total	20.6	1.8	20.3	21	17	27
Hand length	Male	189.3	14.2	185.3	193.4	163.5	244.5
	Female	171.5	9.2	168.9	174.1	155.6	210.4
	Total	180.4	14.9	177.5	183.4	155.6	244.5
Hand breadth	Male	85.6	4.1	84.4	86.8	74.1	95
	Female	76.1	4.1	74.8	77.2	67.7	91.4
	Total	80.8	6.3	79.6	82.1	67.7	95
Second finger length	Male	61.7	4	60.5	62.8	55.3	76.9
	Female	59.9	5.2	55.4	58.4	47.6	79.8
	Total	59.3	5.2	58.3	60.3	47.6	79.8
Third finger length	Male	74.4	4.3	73.3	75.6	65.6	83.6
	Female	69.3	4.5	68	70.6	60.1	80.4
	Total	71.8	5.1	70.8	72.9	60.1	83.6
Forth finger length	Male	80.2	5.1	87.7	81.7	65.7	90.5
	Female	74.5	4.5	73.2	75.8	65.1	86.7
	Total	77.3	5.6	76.2	78.5	65.1	90.5
Fifth finger length	Male	73.3	4.3	72.1	74.5	65.3	84
	Female	67	5.7	65.3	68.6	40.4	79.3
	Total	70.1	5.9	69	71.3	40.4	84

Table 1 includes descriptive statistics of age, stature, left upper limb length, left arm length, left forearm length, left hand length, left hand breadth and the lengths of left 2nd to 5th fingers in both genders.

Table 2 illustrates the correlation coefficient between the stature and upper limb dimensions in both genders.

We combined regression formulas to estimate the stature from different dimensions as below:

MALE: Stature (cm) = {UL (cm) × 0.822}
+ {HL (mm) × 0.237} + 68.229

EXP: $S = (75 \times 0.822) + (185.70 \times 0.237) + 68.229 = 173.8899$ cm
(real stature = 174 cm)

FEMALE: Stature (cm) = {UL (cm) × 0.797}
+ {HL (mm) × 0.277} + 58.609

EXP: $S = (74.5 \times 0.797) + (181.50 \times 0.277) + 58.609 = 168.2610$ cm
(real stature = 168 cm)

TOTAL: Stature (cm) = {HL (mm) × 0.369}
+ {HB (mm) × 0.469} +64.283 (UL, upper limb; HL, hand length; HB, hand breadth)

Table 3 lists the linear regression equation for stature estimation based on the upper limb dimensions in both genders with separate regression equations for each dimension in each sex group.

4. Discussion

Various studies have been carried out to estimate the stature from body remains such as long bones, clavicle, foot, vertebral column, scapula, and cephalofacial anthropometry and one of them is hand(1,2,3,4,18,19). Studies that have been carried out to investigate the relation between hand dimensions and stature have emphasized the effect of genetics, nutrition, environment, gender, age, and physical activity.

According to the effect of some parameters on hand dimensions and stature- such as race and gender- this study was done on 100 Iranian students between 21 and 26 years.

Table 2
Correlation coefficiency (r) between stature and anthropometric parameters of left upper limb in both genders.

Sex	ULL	AL	FAL	HL	HB	2nd.FL	3rd.FL	4th.FL	5th.FL
Male	**0.635	**0.602	*0.354	**0.696	* 0.310	**0.664	**0.674	**0.484	**0.483
Female	**0.735	**0.669	*0.299	**0.724	**0.509	**0.436	**0.644	**579/0	0.317*
Total	**0.832	**0.759	**0.580	**0.816	**0.736	**0.696	**0.759	**0.682	**0.570

$^{*}p > 0.05$ $^{**}p < 0.01$.
hand length (HL), hand breadth (HB), upper limb length (ULL), arm length (UAL), forearm length (FAL), 2nd. to 5th fingers (FL).

Table 3
Regression equation for stature estimation using anthropometric parameters of left upper limb in both sexes.

Male	Female
$S = (HL \times 0.315) + 115.996$	$S = (ULL \times 1.332) + 68.602$
$S = (3th.FL \times 0.834) + 108.718$	$S = (HL \times 0.501) + 76.279$
$S = (2nd.FL \times 0.988) + 103.222$	$S = (AL \times 1.911) + 98.099$
$S = (ULL \times 1.231) + 81.532$	$S = (3th.FL \times 0.901) + 95.058$
$S = (AL \times 1.886) + 107.344$	$S = (4th.FL \times 0.814) + 105.715$
$S = (4th.FL \times 0.731) + 121.260$	$S = (HB \times 0.799) + 102.885$
$S = (5th.FL \times 0.779) + 127.344592$	$S = (2nd.FL \times 0.486) + 129.578$
$S = (FAL \times 1.886) + 107.344$	$S = (5th.FL \times 0.385) + 140.257$
$S = (HB \times 0.481) + 134.433$	$S = (FAL \times 1.489) + 132.838$

HL: hand length; HB: hand breadth; 5th.FL: fifth finger length; 4th.FL: fourth finger length; 3th.FL: third finger length; 2nd.FL: Second finger length; (mm)ULL: upper limb length; AL: Arm length; FAL: Forearm length; *S*: Stature; (cm).

correlation coefficient (r) of 0.62 in males and 0.69 in females for length of the hand and 0.39 in males and 0.4 in females for breadth of the hand. On the other hand, the correlation coefficient was higher in females, which is in accordance with the results of Ilayperuma et al.,[21] but in contrary to the result of Sanli et al.[16]

In our study, hand length ($r = 0.696$) had the highest and hand breadth ($r = 0.310$) the lowest predictors of stature for male subjects and the upper limb length ($r = 0.735$) had the highest and forearm length ($r = 0.299$) the lowest one in females.

In Ozaslan et al.[7] study, the highest values were associated with upper limb length (62%) and forearm length (38%) for males and upper limb length (64%) and arm length (43%) for females.

In our study, the relation between middle finger length (MFL) and stature was stronger in males ($r = 0.674$) than females ($r = 0.644$).

Table 4
Comparison between mean of stature, hand length, hand breadth and their correlation coefficients (r) in some related studies.

Authors	Year	Country	Mean stature (cm)		Mean HL(cm)		Between stature and R HL		Mean HB(cm)		R between stature and HB	
			Male	Female	Male	Female	Male	Female	Male	Female	Male	
Bhatnagar et al.[23]	1984	India	167.52	_	19.30	_	_	_	8.32	_	_	_
Abdel-Malek et al.[16]	1990	Egypt	172.8	158.9	19.98	18.25	_	_	8.15	7.39	0/39	0/4
jasuja et al.[12]	2004	India	175.2	159.7	19.793	17.47	0/452	0/557	_	_	_	_
Sanli et al.[14]	2005	Turkey	175.056	159.96	20.878	18.958	0/722	0/709	_	_	_	_
Krishan et al.[8]	2007	India	168.24	155.72	18.21	16.80	_	_	8.09	7.29	0.537	0.403
Rastogi et al[15]	2008	India	171.60	158.66	18.87	17.01	0.664	0.739	7.96	7.06	0.592	0.378
Qgnihotri et al.[10]	2008	India	173.99	159.56	18.90	17.22	0.594	0.739	8.42	7.42	_	_
Ilayperuma et al.[9]	2009	Sri Lanka	170.14	157.55	19.01	17.62	0.58	0.59	_	_	_	_
Hqbib et al.[19]	2010	Egypt	174.61	160	19.36	17.62	0.697	0.495	_	_	_	_
Our study	2010	Iran	175.65	162.14	18.93	17.15	0.696	0.724	8.56	7.61	0.31	0:509

HL, hand length; HB, hand breadth; *S*, stature.

In the present study, mean of stature and all anthropometric parameters of upper limb were higher in males. Similar result has been obtained by Krishan et al.,[12] Jasuja et al.,[15] and Kanchan et al.[18] It is due to the fact that fusion of epiphyses of the bones occurs earlier in girls; in other words, boys have a chance of bone growth for two more years in comparison to the girls.[20]

The mean length of the hand was 18.9 cm in males and 17.22 cm in females in the first study; these measures were 19.01 cm vs 17.62 cm, 208.78 mm vs 189.58 mm, 19.793 cm vs 17.47 cm and 19.36 cm vs 17.62 cm in the second, third, and fourth study, respectively. The results of the first study were similar to ours (18.93 cm in males and 17.15 cm in females).

The correlation coefficient (r) between stature and length of the hand was 0.594 in males and 0.739 in females in the first study; the measures were reported to be 0.58 vs 0.59, 0.722 vs 0.709, 0.452 vs 0.557 and 0.670 vs 0.563 in the second, third, fourth and fifth study, respectively. In our study, it was 0.696 in males and 0.724 in females.

The mean breadth of the hand was 8.42 cm in males and 7.42 cm in females in the first, 7.96 cm vs 7.06 cm in the second, 8.09 cm vs 7.29 cm in the third, and 8.15 cm vs 7.39 cm in the fourth study. The results of the first study were similar to ours (8.56 cm in males and 7.61 cm in females).

The correlation coefficient(r) between stature and breadth of the hand was 0.592 in males and 0.378 in females in Rastogi et al.,[17] 0.537 in males and 0.403 in females in Krishan et al.[19] and 0.39 in males and 0.4 in females in Malek et al.[13] study. Results of Malek et al.[13] study were in accordance with ours (0.31 in males and 0.509 in females). According to these results, estimation of the stature based on the breadth of the hand is less valuable than its length.

In our research the correlation coefficient (r) between stature and length of the hand was greater than its breadth in both genders. The same result was achieved by Malek et al.,[13] with

In Rastogi et al.[9] study, the highest correlation coefficient was ($r = 0.696$) for right MFL in men and the lowest correlation coefficient was ($r = 0.504$) for left MFL of females.

In the present study, length of the upper limb and hand length together were the most applicable and valuable predictors of the stature in each sex ($r = 0.738$) and hand length and breadth together were the most promising and validating predictors of the stature in total cases ($r = 0.848$).

Amongst all researches discussed here, due to the less variety of the hand dimensions, the length and breadth of the hand had been reported to be the best predictors of the stature.[13,16,21–23]

In our study, subjects were categorized into three age groups (21–22, 23 to 24 and 25–26 years). The models for both genders in each age group were not consistent with that of the general models. Similar results were obtained by Agnihotri et al.,[14] which may be attributed to the non homologous distribution of the age and lack of a relationship between age and estimation of the stature. It is to be noted that more researches in this regard are warranted.

According to the limited time, and relative papers mentioned above, we chose only left hand in right-handed persons (right-handed students were more than left handed ones). So our results are not useful for left hand, because of the effect of dominant hand in hand width. Although if we had enough time, it would be better to study on both hands.

Comparisons between our results and some related articles are shown in Table 4.

5. Conclusion

According to our results, along with factors such as long bones, the stature of the body can be estimated by anthropometric evaluation of upper limb using the abovementioned formulas.

Our study was done on subjects aged between 21 and 26 years. As with increasing the age, stature is decreased in both sexes[22]; therefore, our results may not be useful in some age groups. Also, the present study has been performed on a live people, and it is to be noted that the height (stature) of the corpse is changed based on the environmental situations and post-mortem period. So when body remains are found in natural events and mass disasters, attained results in our study should be carefully applied based on the corpse situations.

Conflict of interest

None declared.

Funding

We had no financial support for this research.

Ethical approval

none.

Acknowledgment

We would like to thank medical students for their cooperation in the conduction of this study.

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